



U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON

2011

Do Photovoltaic Energy Systems Increase Home Values?

Ben Hoen

Lawrence Berkeley National Laboratory

October 1st, 2011

Lawrence Berkeley National Laboratory

Member of the National Laboratory System supported by the U.S. Department of Energy through its Office of Science.

Located in Berkeley, California

Founded in 1931 by Ernest Orlando Lawrence

Annual Budget of \$811 Million

4,200 Employees and 800 University Students

11 Nobel Laureates

24 Divisions and Departments

“To achieve our energy and climate goals, we need a strong and sustained commitment to research and development. These investments are needed for our country’s future economic prosperity, energy security, and environmental sustainability”

Steven Chu, Secretary of Energy, January 21, 2010

Do Photovoltaic Energy Systems Increase Home Values?

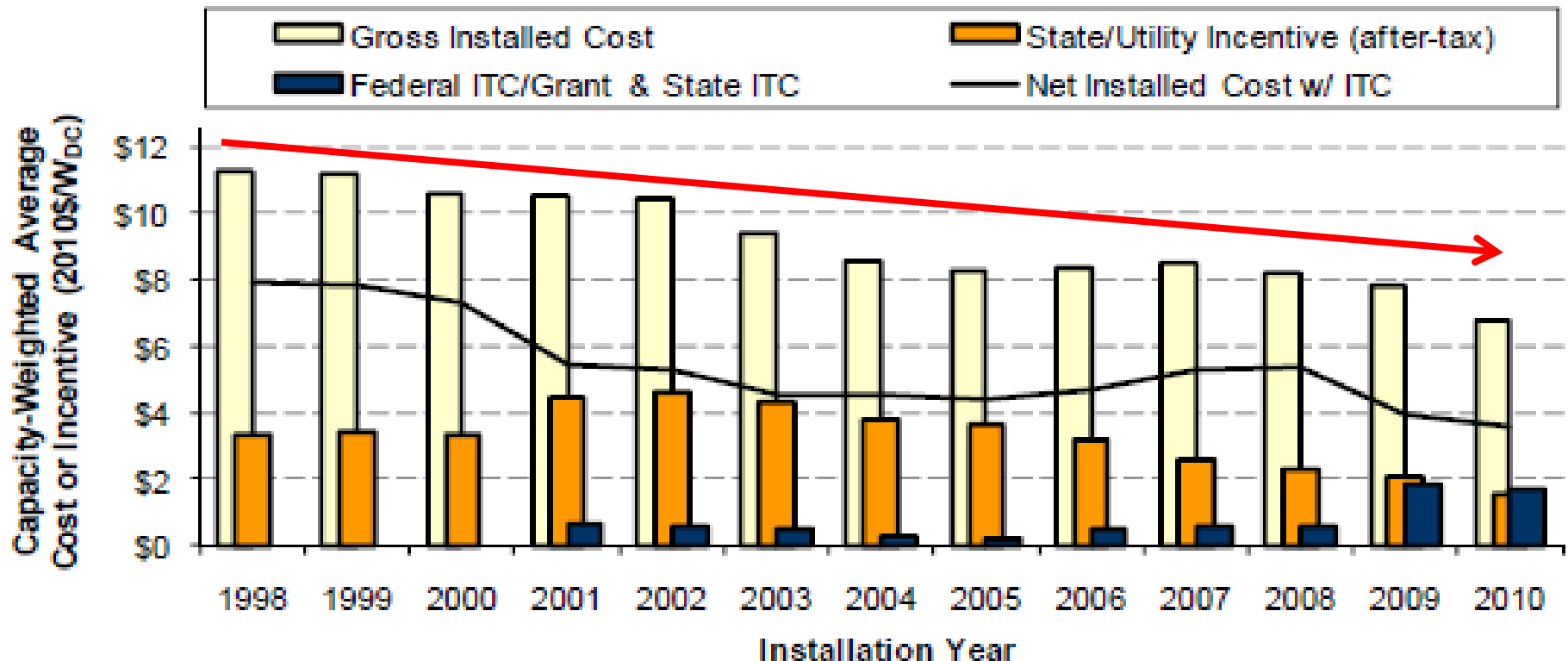
- **Residential PV Market Summary**
- There Are Still Significant Market Barriers
- Previous Literature On Impacts To Home Values
- LBNL Research Findings
- Where Do Stakeholders Go From Here?
- Questions?

What is a Watt?

- A Watt is a unit of electrical energy (or “power”).
- PV systems are rated based on the amount of Watts they can produce under perfect conditions.
- The higher the Watt rating, the more energy a PV system will produce.
- PV systems are priced in dollars per Watt or \$/Watt

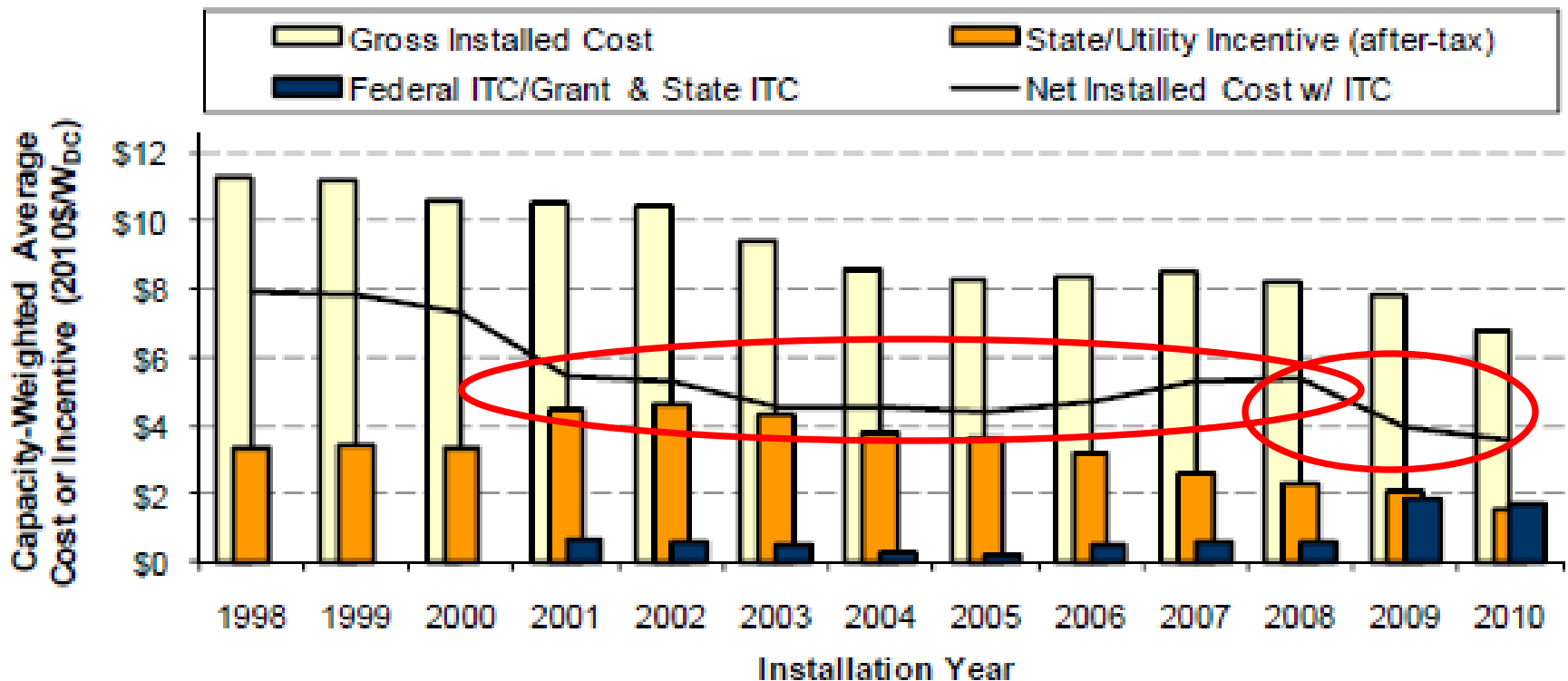


Average Gross Installed Costs For Residential PV Have Declined Through 2010



Source: Lawrence Berkeley National Laboratory (2011) *Tracking the Sun III*

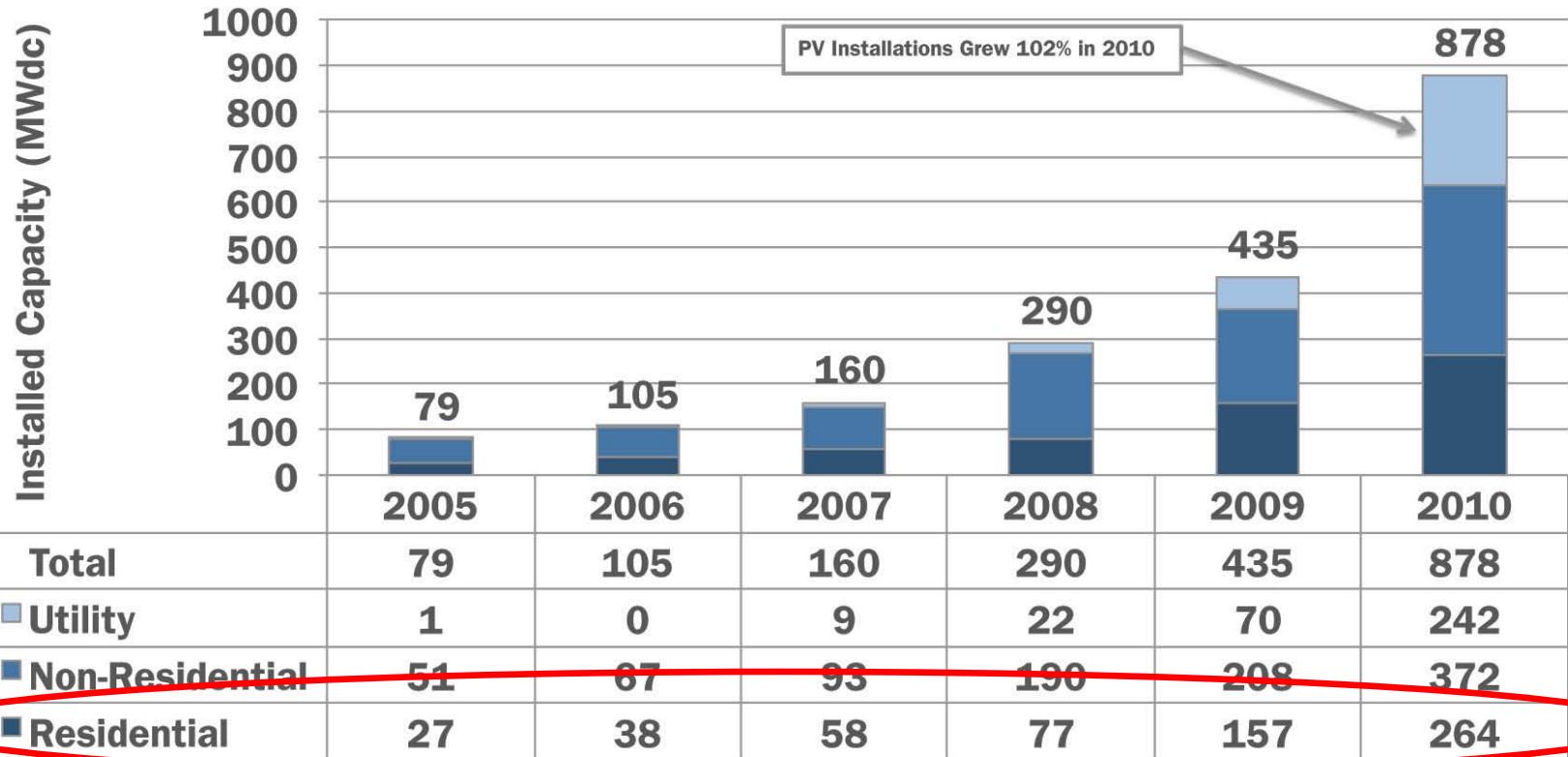
Average Net Installed Costs Have Remained Fairly Flat Through 2008 Near \$5/Watt Yet Declined Sharply Thru 2010 To Near \$4/Watt



Net Installed Cost = Average cost of installing PV, after deducting available state/federal incentives

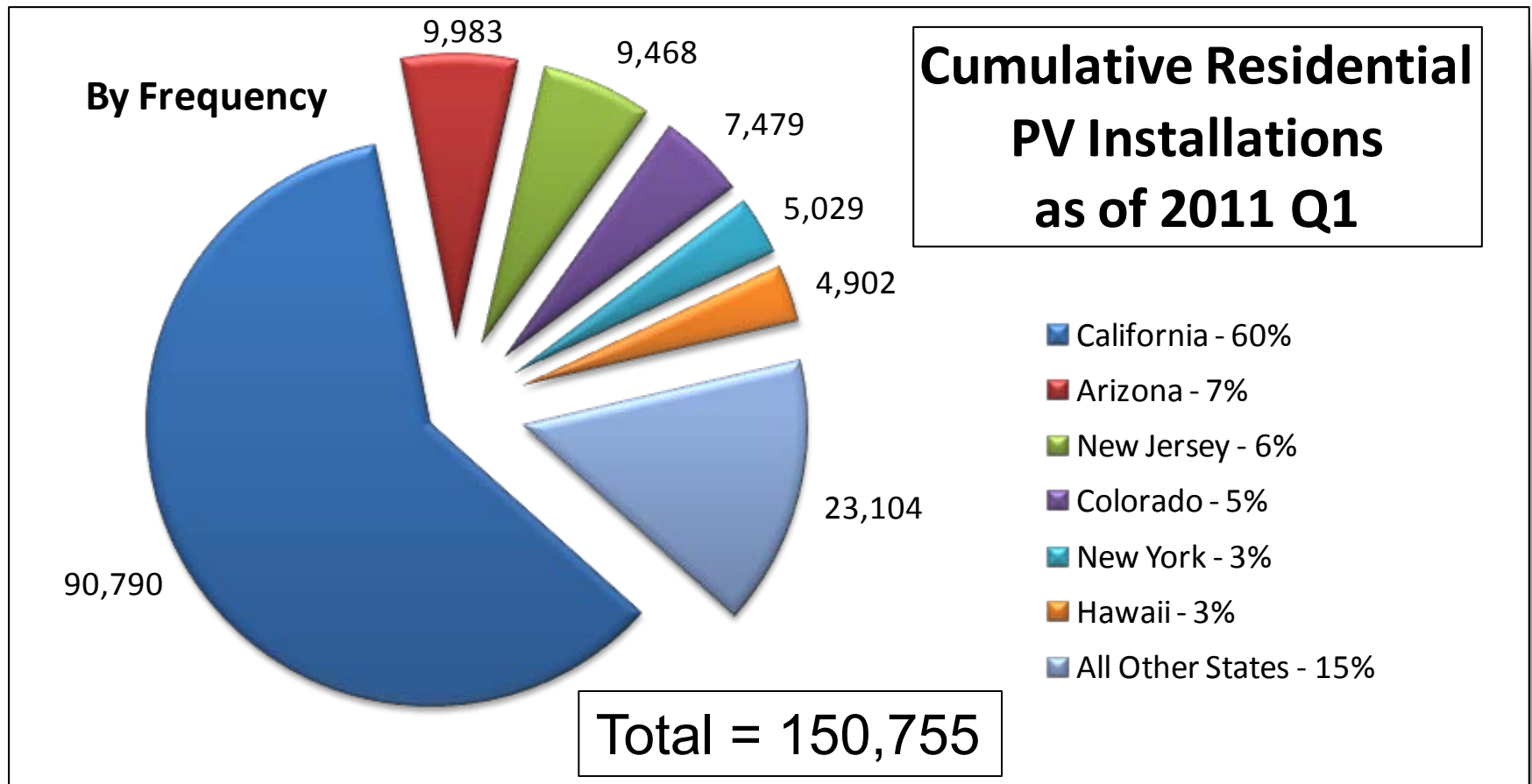
Solar PV Installations Have Been Increasing Dramatically In The US, Including Residential

Annual PV Installed Capacity by Market Segment, 2005-2010



Source: Solar Energy Industries Association, U.S. Solar Market Insight™: 2010 Year-In-Review

Through 2011 There Are 150,000 Residential Installations. Mostly In California, Yet Other States Are Growing



Source: Solar Energy Industries Association

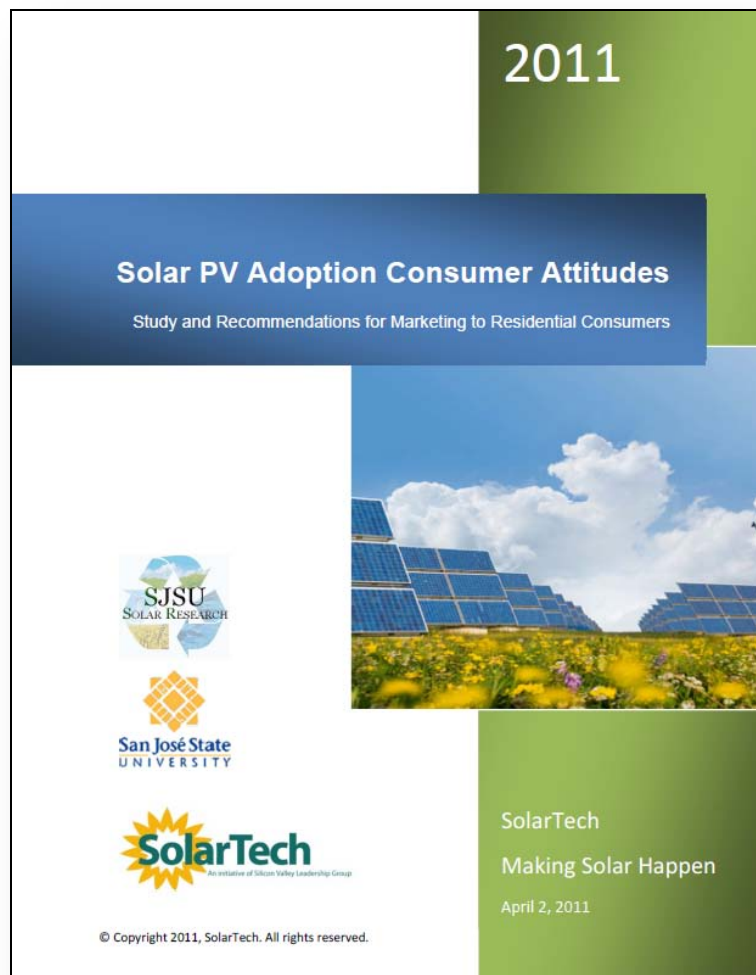
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Barriers To PV Adoption Are Multi-Faceted

- Lack of government policy
- Lack of consumer awareness
- High cost of solar
- Difficulty overcoming established energy systems
- Inadequate financing options
- Failure to account for all costs and benefits of energy choices
- Inadequate workforce skills and training
- Lack of adequate codes, standards, and interconnection and net-metering guidelines
- Poor perception by public of renewable energy system aesthetics
- Lack of stakeholder/community participation in energy choices

There Is A Perception That PV Systems Are Expensive



Survey of residents of Santa Clara County, CA

- Santa Clara has 15 MW of PV installed (~3,000 systems), and therefore a high likelihood of PV familiarity
- 82% perceived PV as “expensive”
- 11% perceived PV as “affordable”

Source: www.SolarTech.org

Homeowners/Builders May Be Hesitant To Invest Given Uncertain Resale Values

The Washington Post

[Back to previous page](#)

Is green good for home resale value?

By [Kenneth R. Harney](#), Published: August 26

Home energy efficiency and sustainability have been major policy priorities for the Obama administration, but lurking in the background are two pesky questions: Beyond the documentable savings on utilities bills, do such steps add to the resale value of a home? And do they make it easier to sell your property?

Housing groups and housing officials say definitive data covering multiple regions of the country are scarce. But some localized research projects in Oregon

Although Change is Proposed, Appraisers Have Been Slow To Account For Energy Features In Their Residential Valuations

The New York Times



August 25, 2011

Strange Bedfellows Back Bill Using Mortgages to Spur Energy Retrofits

By JASON PLAUTZ of

A Senate bill that would allow energy-saving retrofits to be factors in mortgage underwriting has quickly attracted a diverse set of enthusiastic supporters that range from the conservative U.S. Chamber of Commerce to the liberal Center for American Progress.

The "Sensible Accounting to Value Energy Act," or SAVE Act, which is expected to be introduced this fall by Sen. Michael Bennet (D-Colo.), would require federal loan agencies to include projected energy costs when financing a house, essentially offering better mortgage values on properties that are more energy efficient.

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Nevin & Watson (1998)

"Evidence of Rational Market Values for Home Energy Efficiency"

Evidence of Rational Market Valuations for Home Energy Efficiency

According to this study, residential real estate markets assign to energy-efficient homes an incremental value that reflects the discounted value of annual fuel savings. The capitalization rate used by homeowners was expected to be 4%–10%, reflecting the range of after-tax mortgage interest rates during the 1990s and resulting in an incremental home value of \$10 to around \$25 for every \$1 reduction in annual fuel bills. Regression analysis of American Housing Survey data confirms this hypothesis for national and metropolitan area samples, attached and detached housing, and detached housing subsamples using a specific fuel type as the main heating fuel.

Investments in high-efficiency heating and air conditioning equipment, insulation, and other energy-efficient home features have historically been justified and promoted based on the investment payback to the homeowner. The payback period is the number of years needed to fully recover energy efficiency investments through reduced fuel costs. More recently, the U.S. Environmental Protection Agency initiated a marketing program called "ENERGY STAR Homes." This effort teaches that energy-efficient homes produce immediate positive cash flow for home

buyers because the reduction in monthly fuel bills more than offsets the higher monthly mortgage payment needed to finance such investments. Some home buyers, however, still hesitate to invest in energy efficiency because they are uncertain that they would stay in their homes long enough to recover their investment through lower fuel bills and that they could recover an investment in energy efficiency when they sell their homes. Standard underwriting criteria for home mortgages can also increase the down payment requirements or mortgage insurance

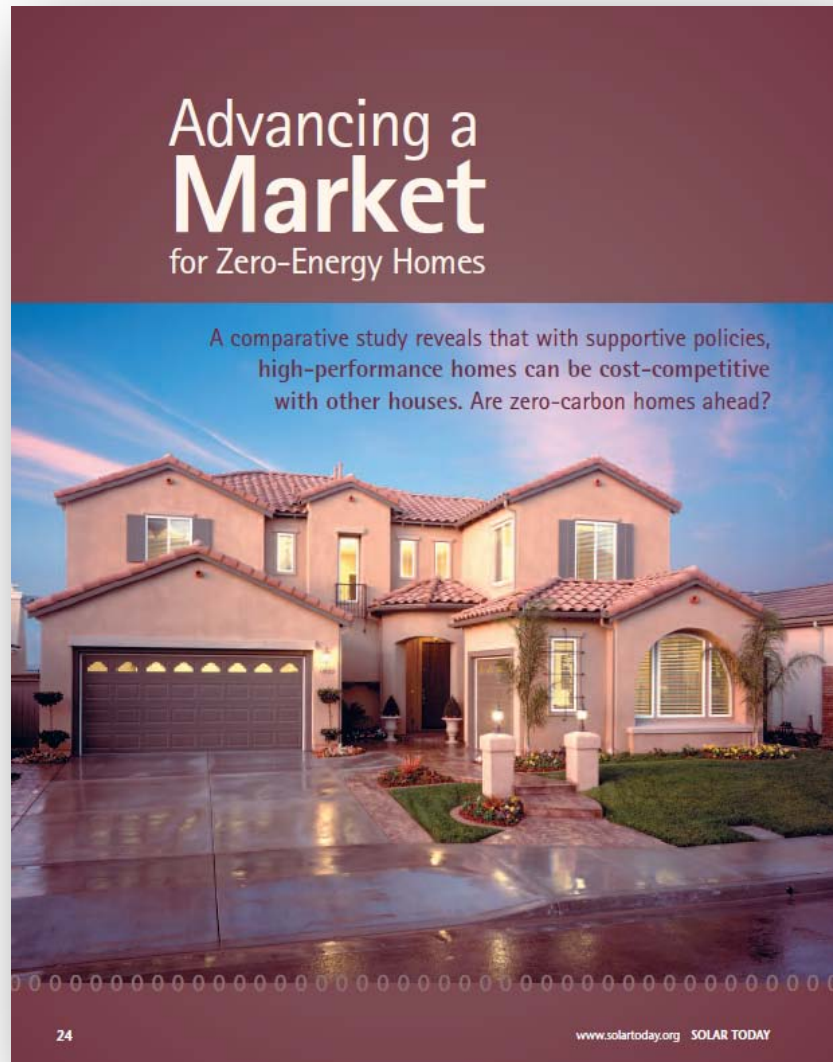
Rick Nevin is a vice president with the ICF Consulting Group, Fairfax, Virginia. He specializes in managing and conducting financial, statistical, and economic analyses for public and private sector clients. He was the project manager and principal author of the Regulatory Impact Analysis for the Department of Housing and Urban Development's proposed rule for lead-based paint hazard evaluation and control. He is also managing a variety of research and analysis tasks to develop and expand accessible home financing under the Environmental Protection Agency's "ENERGY STAR Homes" program. Mr. Nevin earned an MBA in management from Northwestern University, Evanston, Illinois, and a BA and MA in economics from Boston University. Contact: ICF Consulting Group, ICF, Inc.; 9300 Lee Highway, Fairfax, VA 22031-1207. (703) 934-3000. Fax 934-9740. Nevin@icfkaiser.com.

Gregory Watson is a senior associate with the ICF Consulting Group. He was a contributor to an annual compendium of federal, state, and local government finance statistics published by the U.S. Advisory Commission on Intergovernmental Relations and is currently conducting a statistical analysis for the Department of Housing and Urban Development, examining changes in the American housing stock. He earned an MA in economics from the University of Wisconsin, Madison, and a BA in economics from the University of Chicago.

- Multiple models with sample sizes ranging from 600 to 46,000 across various parts of the country
- Concluded 20:1 reasonable average for sales price to energy savings ratio given a 5% after tax mortgage rate
- This implies for every \$1 saved via energy efficiency the home's value is increased by \$20

Farhar and Coburn (2008)

“A New Market Paradigm for Zero-Energy Homes: A Comparative Case Study”



Gains in Property Values and Length of Ownership for HPHs and Comparison Homes (as of 2/7/05)

Variable	High-Performance Homes (n=15)	Comparison Homes (n=12)
Original price (mean)	\$556,344	\$598,028
Length of ownership (mean)	22.5 mos.	28.1 mos.
Resale price (mean)	\$862,853	\$862,590
Mean \$ gain in property value	\$306,510	\$262,968
Mean percent gain in property value	55.4%	44.7%
Mean \$ gain per month owned	\$14,492	\$9,301

Dastrop, Ziven, Costa & Kahn (2010)

“Understanding the Solar Home Price Premium”



E³ WP-001

Understanding the Solar Home Price Premium: Electricity Generation and “Green” Social Status

Samuel Dastrop, Joshua Graff Zivin,
Dora L. Costa, and Matthew E. Kahn

December 2010

This paper is part of the UC Center for Energy and Environmental Economics Working Paper Series. UCE³ is a joint venture of the UC Energy Institute and the UC Santa Barbara Bren School of Environmental Science and Management. UCE³ fosters research and collaboration at all UC campuses in the area of energy and environmental economics.

UC Center for Energy and Environmental Economics
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www.uce3.berkeley.edu

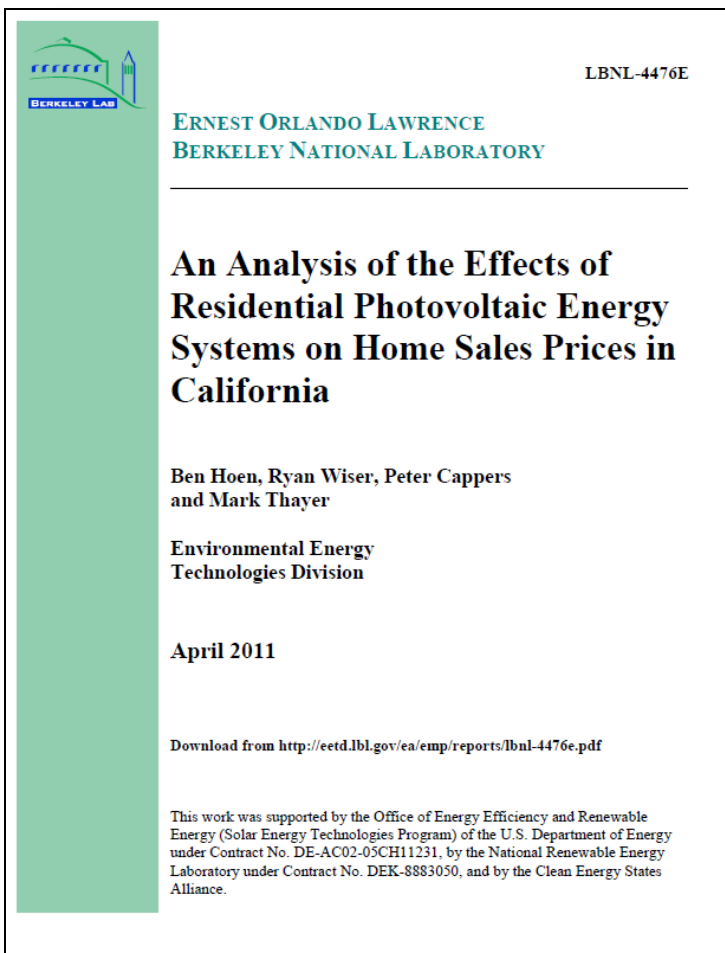
- Investigated 279 PV homes that sold in Greater San Diego
- Found significant difference between PV and non-PV sales prices
- Premiums of approximately 3.5% for PV homes found
- Equates to approximately \$4.40 per installed watt (DC)

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Hoen, Wiser, Cappers & Thayer (2011)

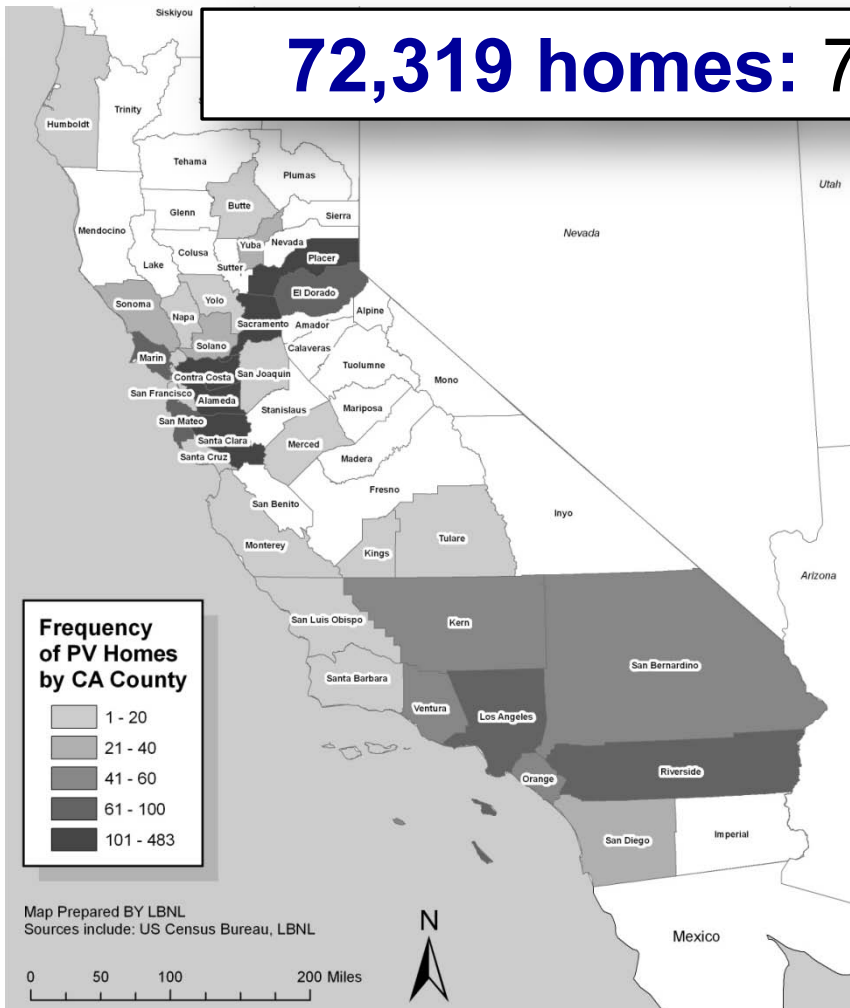
"An Analysis of the Effects of Residential Photovoltaic Energy Systems on Home Sales Prices in California"



- Build on available literature
- Investigate selling prices of homes with PV relative to comparable non-PV homes
- Concentrate on California PV but across multiple counties
- Use a variety of different tests to determine premiums

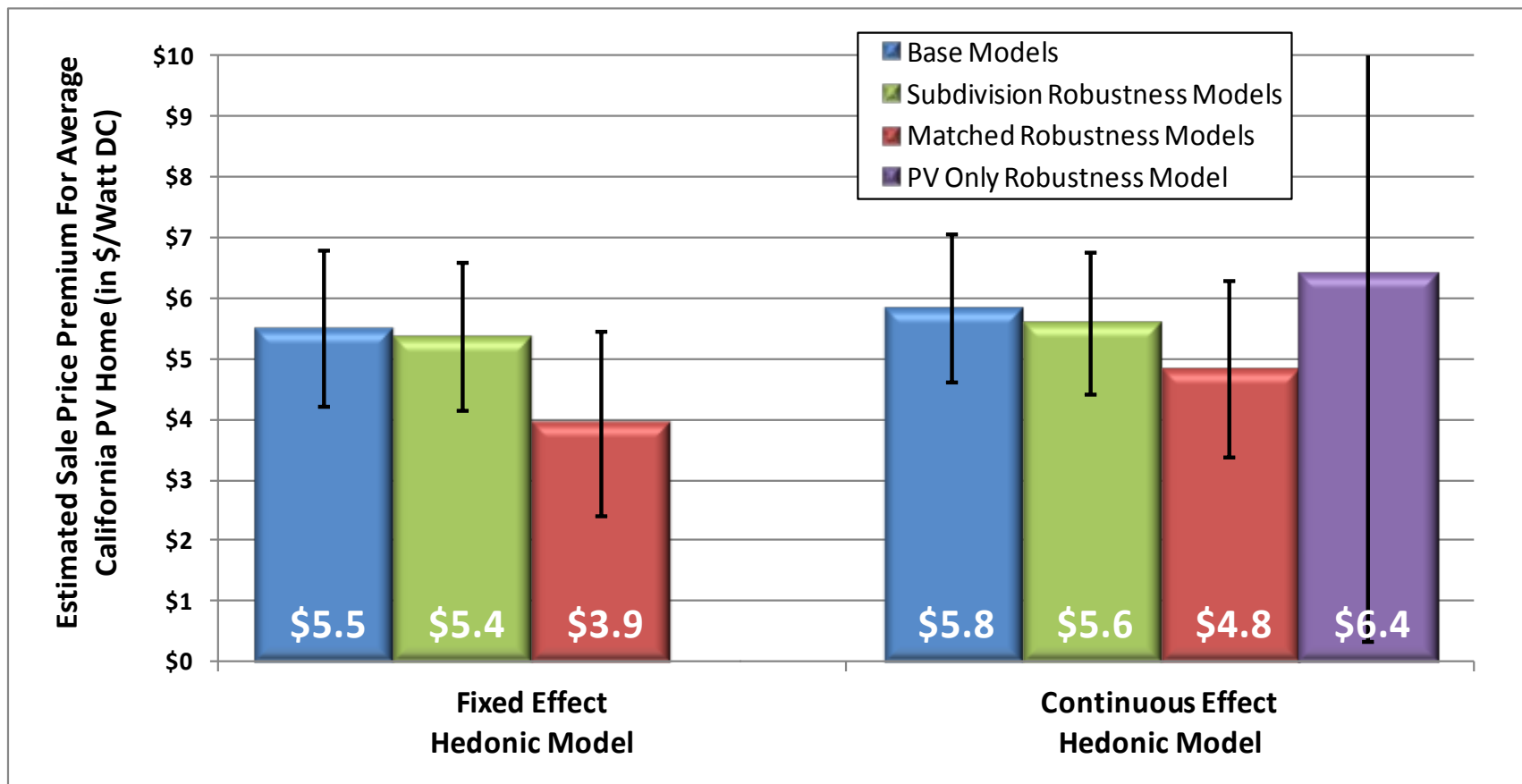
PV Sales Data Are Well Arrayed Across California, Among Home Types, Utility Service Areas, And Years

72,319 homes: 70,425 non-PV; 1,894 PV

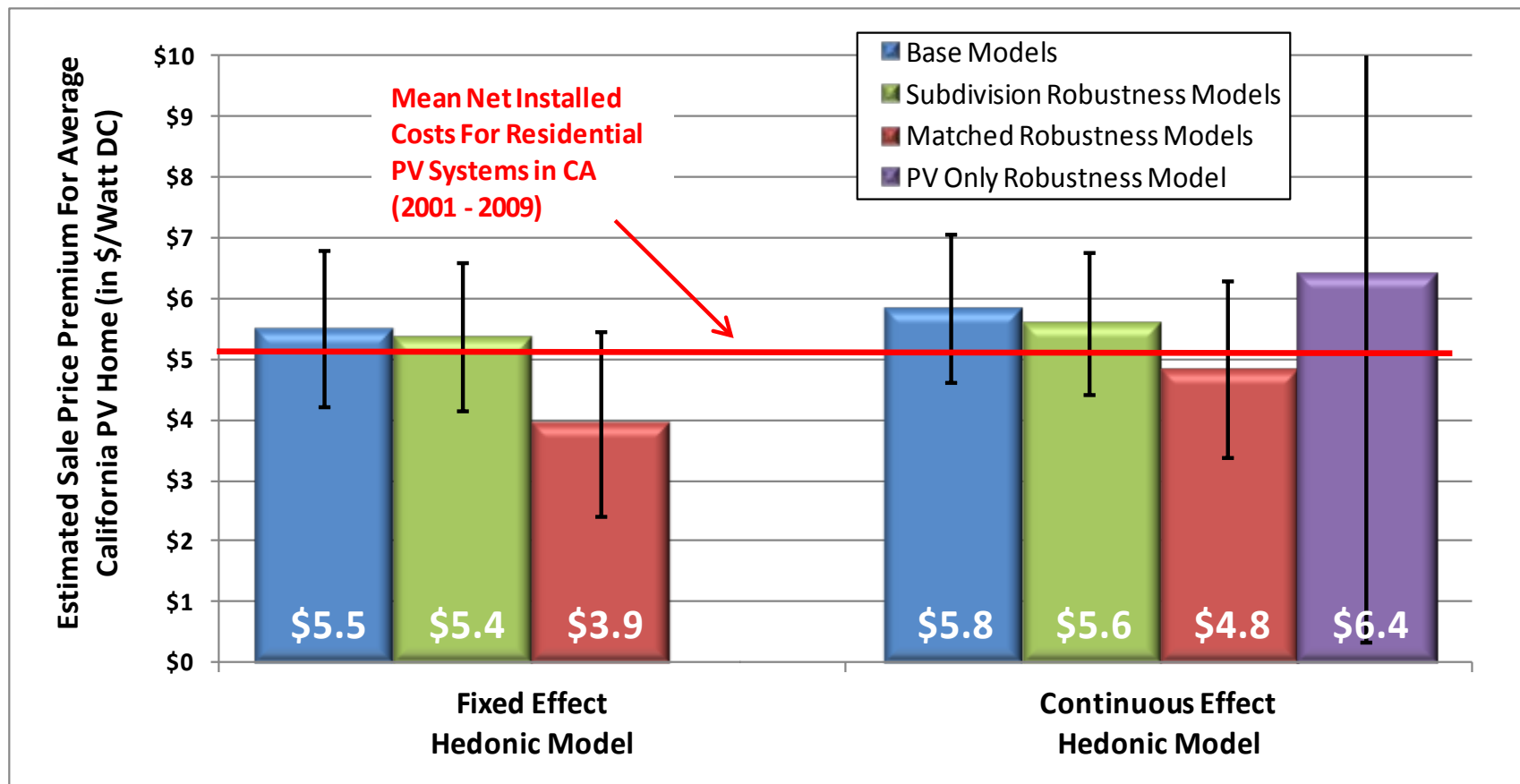


- **31 Counties**
- **4 Different Utility Service Areas:** PG&E, SCE, SDG&E, SMUD
- **11 Years:** 1999-2009
- **50% New Homes**
50% Existing Homes

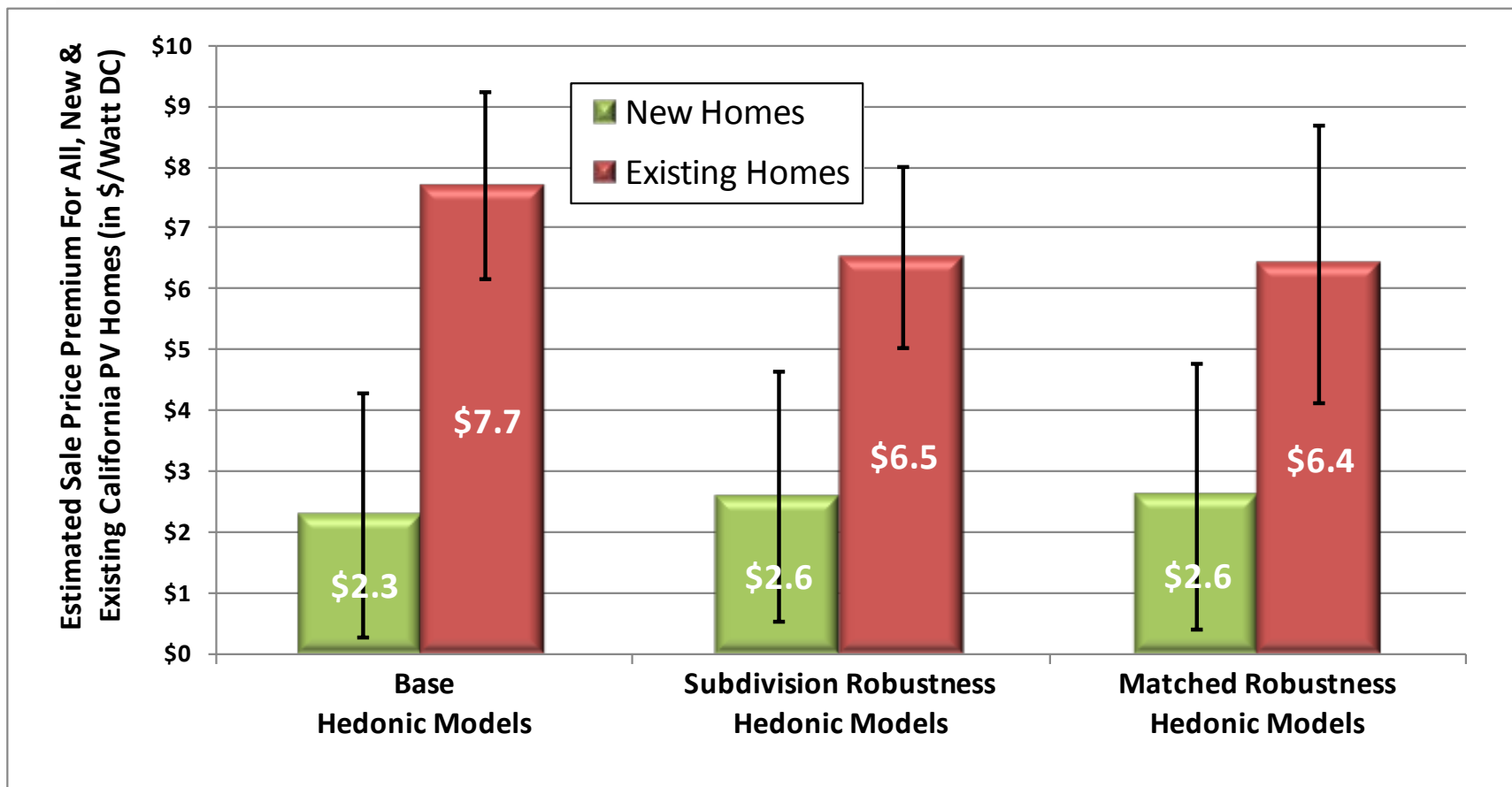
Estimated \$/Watt (DC, STC) Premiums For The Full Sample Are Between \$3.9 and \$6.4



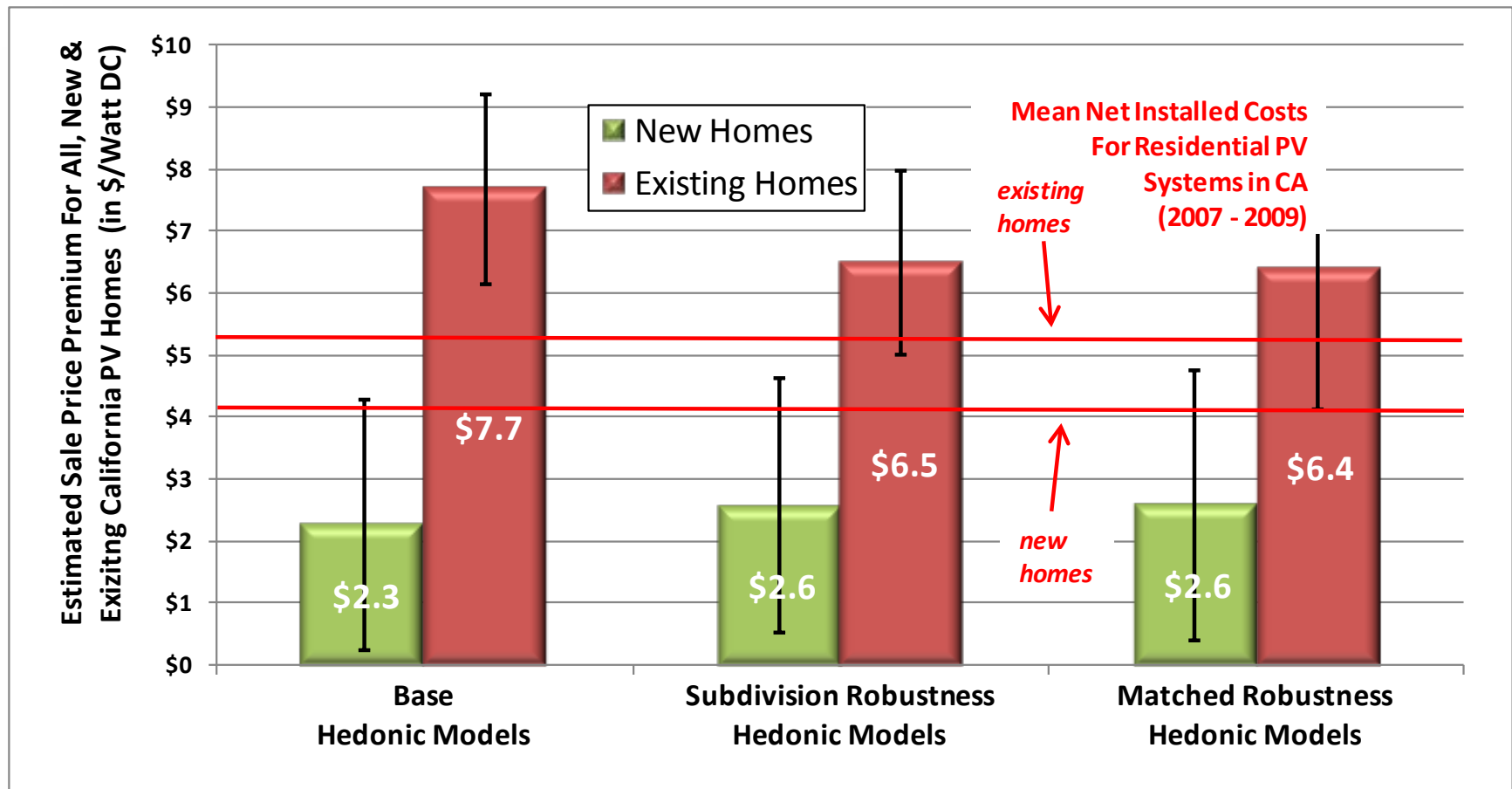
Buyers And Sellers Might Be Using Net Installed Costs As A Price Signal



Large Differences In Premiums Were Found Between New and Existing Homes



Differences Might Be Partly Explained By Disparity In Net Installed Costs



Disparities Might Be Explained By Other Factors Besides Net Installed Cost

New Homes

Increased sales velocity?



Sales agent less familiarity
with PV?



Group PV
with other features?



Less expensive homes =
less discretionary income?



Existing Homes

Highest price?

Homeowner more familiarity
with PV?

Differentiate PV
from other features?

More expensive homes =
more discretionary income?

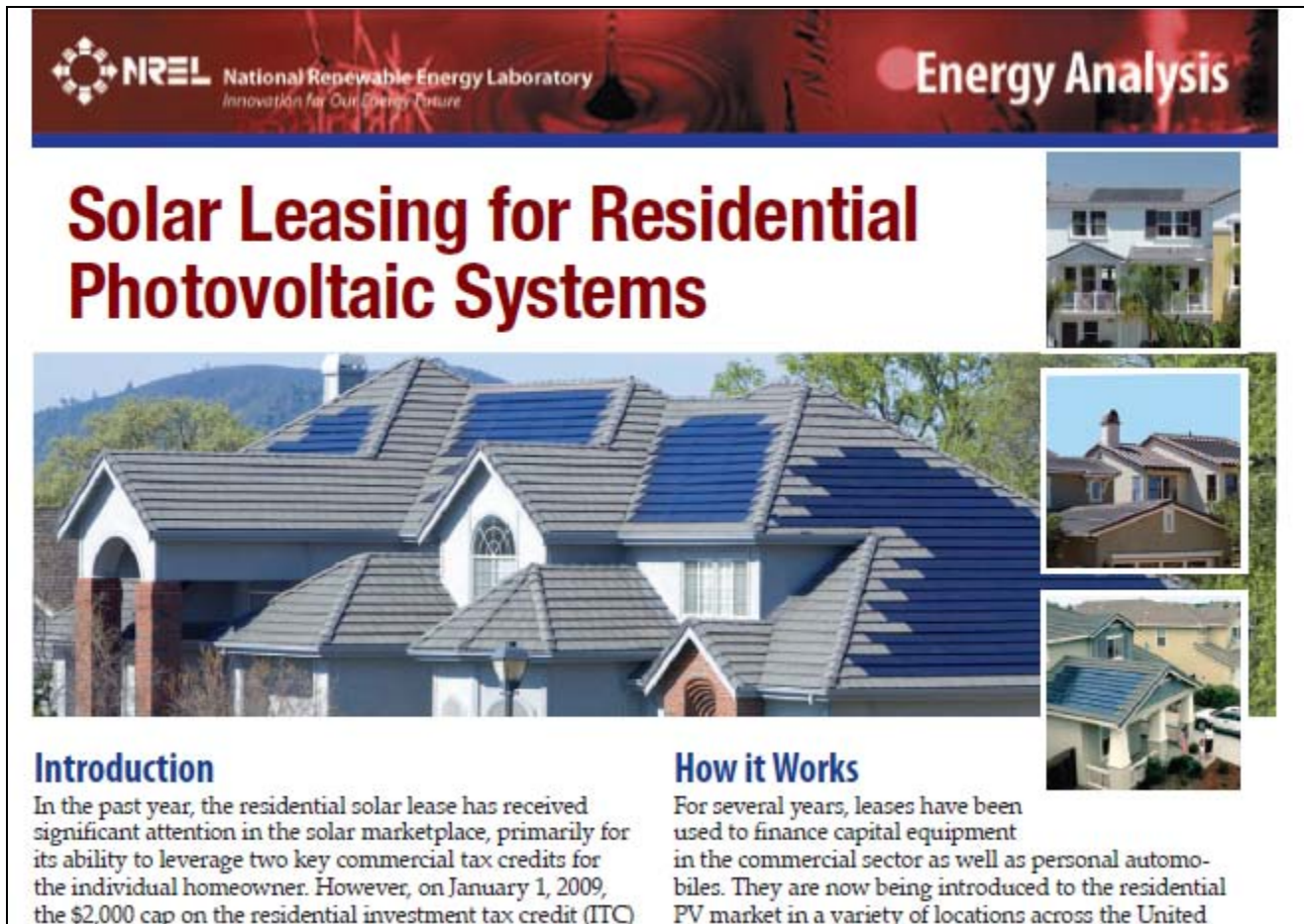
LBNL Report Conclusions

- CA PV homes sold for more than non-PV homes
- Average premiums were ~\$5.5 per Watt
- Existing home premiums were even higher, and new home premiums were lower
- New vs. existing premiums may be partly explained by net installed costs, but also related to varying buyer/seller motivations (e.g., sales velocity)

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Residential Solar Leasing Allows Consumers To Pay Very Little Yet Have A PV System On Their Home



NREL National Renewable Energy Laboratory
Innovation for Our Energy Future

Energy Analysis

Solar Leasing for Residential Photovoltaic Systems



Introduction

In the past year, the residential solar lease has received significant attention in the solar marketplace, primarily for its ability to leverage two key commercial tax credits for the individual homeowner. However, on January 1, 2009, the \$2,000 cap on the residential investment tax credit (ITC)

How it Works

For several years, leases have been used to finance capital equipment in the commercial sector as well as personal automobiles. They are now being introduced to the residential PV market in a variety of locations across the United

Residential Solar Leasing



JOIN THE ROOFTOP REVOLUTION

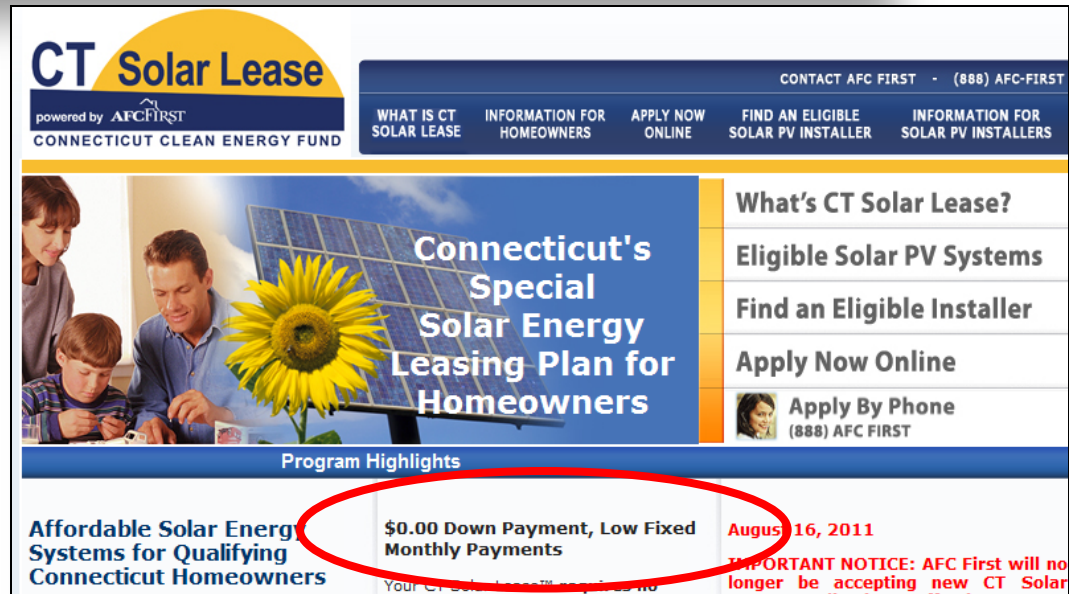
A Sungevity solar plan can set your home free from rising electricity costs.

- Put \$0 down • Get free installation
- Many customers save from day one

Systems are available for sale and for lease to those with good credit.

Request your free iQuote today—get it tomorrow.
Enter your home address. Get an iQuote the very next day by email.

[Get Started](#)



CT Solar Lease
powered by **AFC FIRST**
CONNECTICUT CLEAN ENERGY FUND

CONTACT AFC FIRST - (888) AFC-FIRST

WHAT IS CT SOLAR LEASE | INFORMATION FOR HOMEOWNERS | APPLY NOW ONLINE | FIND AN ELIGIBLE SOLAR PV INSTALLER | INFORMATION FOR SOLAR PV INSTALLERS

Connecticut's Special Solar Energy Leasing Plan for Homeowners

What's CT Solar Lease?

- Eligible Solar PV Systems
- Find an Eligible Installer
- Apply Now Online
- Apply By Phone (888) AFC FIRST

Program Highlights

Affordable Solar Energy Systems for Qualifying Connecticut Homeowners

\$0.00 Down Payment, Low Fixed Monthly Payments

August 16, 2011

IMPORTANT NOTICE: AFC First will no longer be accepting new CT Solar

For Homeowners Who Want to Own A PV System Low-Interest Loan Options Are Often Available

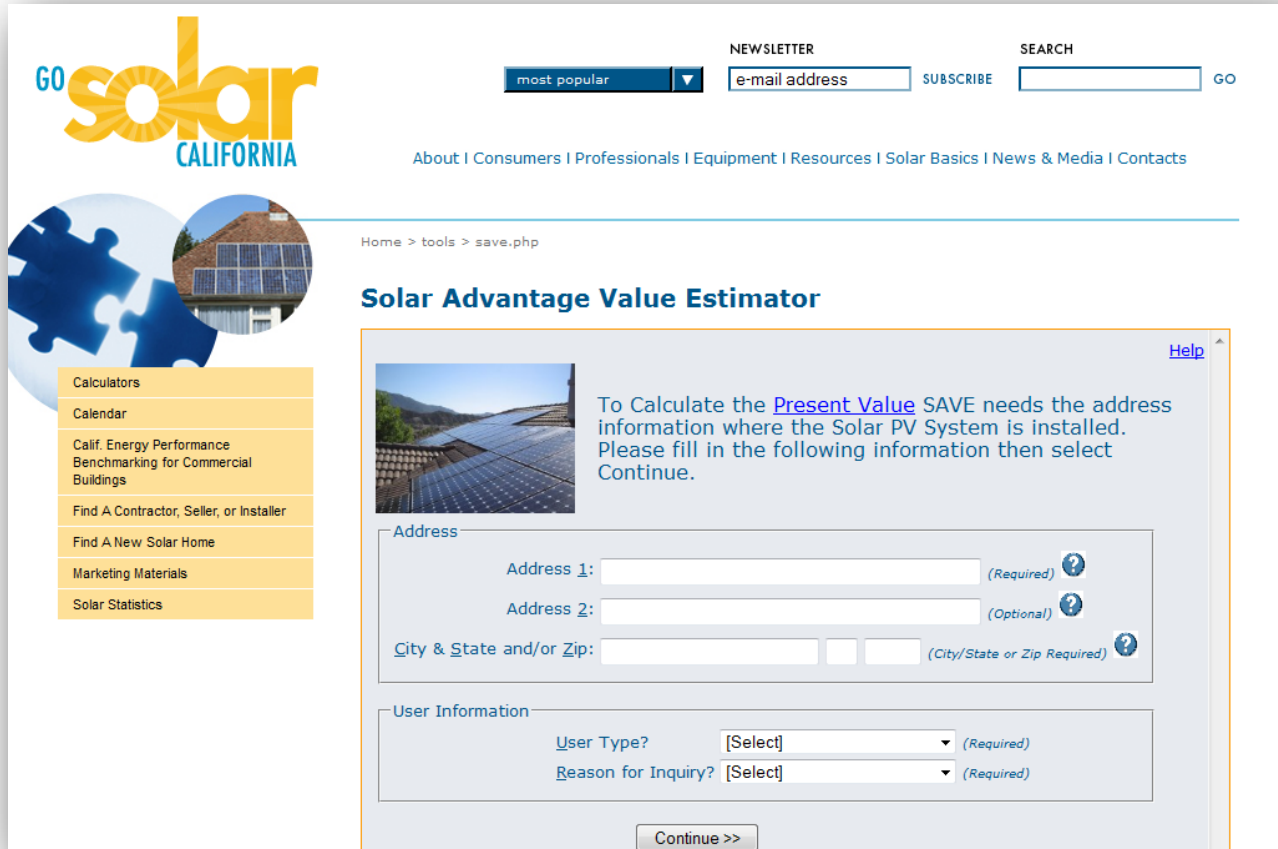
Database of
State
Incentives for
Renewable
Energy



The screenshot shows the DSIRE (Database of State Incentives for Renewables & Efficiency) website. The header features the U.S. Department of Energy logo, the text "Energy Efficiency & Renewable Energy", and logos for IREC (Interstate Renewable Energy Council) and the North Carolina Solar Center. A navigation bar includes links for Home, Glossary, Links, FAQs, Contacts, and About Us. The main content area has a search bar labeled "Search DSIRE" and a link to "View Federal Incentives". On the left, there is a "Resources" sidebar with links to RPS Data, Summary Maps, Summary Tables, Library, What's New?, and Search. Below this is a "myDSIRE" section with a link to "customize DSIRE for your organization". The central part of the page displays a map of the United States with state abbreviations, and a legend indicating "U.S. Territories".

www.dsireusa.org

For California Homeowners Who Own A PV System Or Are Considering It, A Valuation Tool Is Available



The screenshot shows the 'Go Solar California' website interface. At the top, there is a navigation bar with a 'most popular' dropdown, a 'NEWSLETTER' section with an 'e-mail address' input and 'SUBSCRIBE' button, and a 'SEARCH' section with a text input and 'GO' button. Below this is a horizontal menu with links: 'About | Consumers | Professionals | Equipment | Resources | Solar Basics | News & Media | Contacts'. The main content area is titled 'Home > tools > save.php' and 'Solar Advantage Value Estimator'. On the left, a sidebar menu lists: 'Calculators', 'Calendar', 'Calif. Energy Performance Benchmarking for Commercial Buildings', 'Find A Contractor, Seller, or Installer', 'Find A New Solar Home', 'Marketing Materials', and 'Solar Statistics'. The main form area includes a 'Help' link, an image of solar panels, and instructional text: 'To Calculate the Present Value SAVE needs the address information where the Solar PV System is installed. Please fill in the following information then select Continue.' The form has two sections: 'Address' and 'User Information'. The 'Address' section contains three input fields: 'Address 1:' (Required), 'Address 2:' (Optional), and 'City & State and/or Zip:' (City/State or Zip Required). The 'User Information' section contains two dropdown menus: 'User Type?' (Required) and 'Reason for Inquiry?' (Required). A 'Continue >>' button is at the bottom of the form.

GO solar CALIFORNIA

most popular ▼ NEWSLETTER e-mail address SUBSCRIBE SEARCH GO

About | Consumers | Professionals | Equipment | Resources | Solar Basics | News & Media | Contacts

Home > tools > save.php

Solar Advantage Value Estimator

[Help](#)

To Calculate the Present Value SAVE needs the address information where the Solar PV System is installed. Please fill in the following information then select Continue.

Address

Address 1: (Required) ?

Address 2: (Optional) ?

City & State and/or Zip: (City/State or Zip Required) ?

User Information

User Type? (Required)

Reason for Inquiry? (Required)

Continue >>

<http://www.gosolarcalifornia.org/tools/save.php>

A National PV Valuation Tool Will Be Available Soon

SOLAR POWER ELECTRIC		25- and 30-Year Present Value Estimate of Future Energy Production for Photovoltaic Systems			
Solar Resource Calculation		Discount Rate Calculation		Remaining Inputs	
Zip Code	33980	Basis Points (low)	50	User Defined Electricity Cost in ¢/kWh	
System Size in Watts	5,460	Basis Points (high)	200	User Defined Utility Escalation Rate	
Derate Factor (online calculator)	0.770	Basis Points (average)	125	<input checked="" type="checkbox"/> IEA Residential Averages Florida	Calculate 2010 Average State Electricity Rate
Module Degradation Rate	0.5	<input type="button" value="Update 30-Year Fixed Rate"/>	4/12/2011	<input type="checkbox"/> IEA Commercial Averages	
Array Type	Fixed		Rate is Current	Avg 2010 Electricity Cost in ¢/kWh	11.52
Array Tilt (unchecked = latitude)	22.6	FNIM 30-Year Fixed 60-day	4.72	Avg Utility Escalation Rate (1990-2010)	1.99
Array Azimuth (default = South)	180	Discount Rate (low)	5.22	15-Year O&M Expenses ¢/W	\$5.0
<input type="button" value="Calculate PV Production"/>		Discount Rate (high)	6.72	User Defined O&M Expenses ¢/W	<input type="checkbox"/> check to enter value
kWh Produced/Year	6,888	Discount Rate (average)	5.97	Estimated Inverter Replacement Cost	\$1,185.86
		Appraisal Range of Value Estimate		Module Warranty/Years	30
		Low	\$11,325.62	Age of System/Years	0
		Medium	\$12,340.46	Remaining Energy/Years	30
		High	\$13,496.47		

www.spefl.com and <http://www.sandia.gov/pv>

Appraisal Institute Has A Variety Of Courses On How To Analyze The Value of “Going Green”



The screenshot shows the Appraisal Institute website. The header is red with the Appraisal Institute logo and tagline 'Professionals Providing Real Estate Solutions'. Navigation links include Home, Join, Media, Help, and a search bar. A 'Need Help? Call 888-7JOINAI (756-4624)' and a 'CLICK HERE TO LOGIN' button are also present. The main navigation bar is orange and includes links for Membership, Find an Appraiser, Education, Publications & Store, Professional Practice, Lum Library, News & Advocacy, and About Us. The left sidebar is titled 'Education' and lists various resources. The main content area is titled 'EDUCATION' and features a green banner with the text 'Analyze the Value of Going Green with Appraisal Institute Resources' and a small house icon. Below the banner are five green buttons: Welcome, Classroom Education, Online Education, Publications & Podcasts, and Webinar Recordings.

Appraisal Institute®
Professionals Providing Real Estate Solutions

Home | Join | Media | Help | Search
Need Help? Call 888-7JOINAI (756-4624)
[CLICK HERE TO LOGIN](#)

Membership | Find an Appraiser | Education | Publications & Store | Professional Practice | Lum Library | News & Advocacy | About Us

Home > Education > Green Building Resources

FONT SIZE: - +

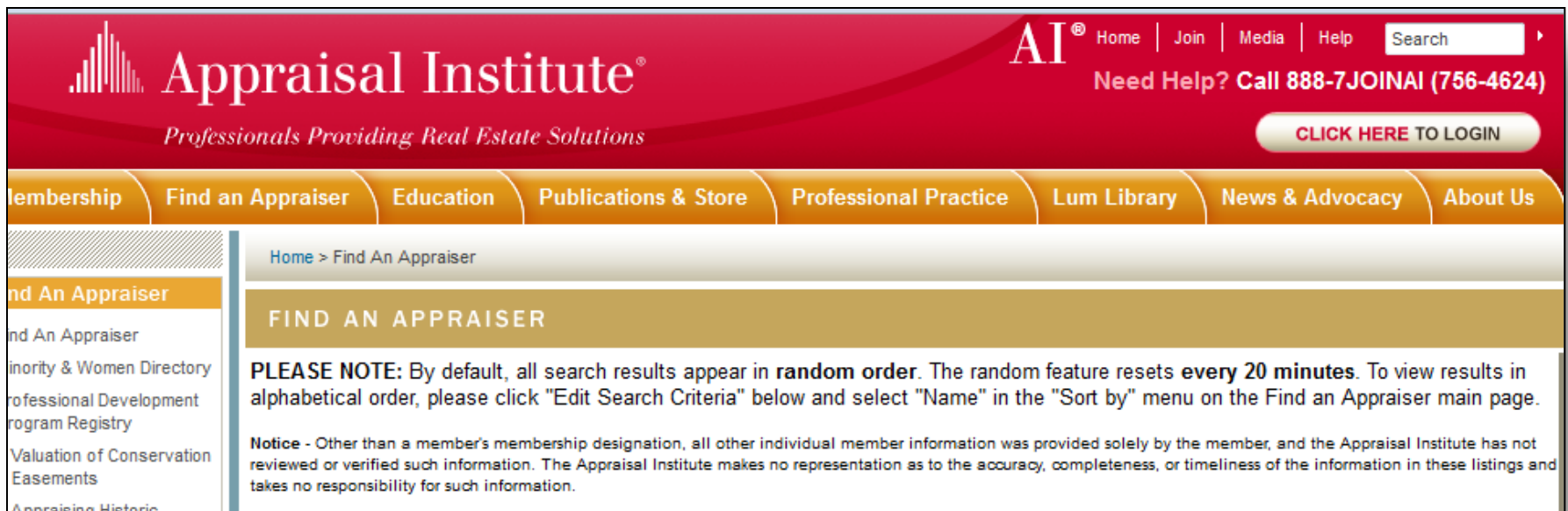
EDUCATION

Analyze the Value of Going Green with Appraisal Institute Resources

Welcome | Classroom Education | Online Education | Publications & Podcasts | Webinar Recordings

www.appraisalinstitute.org

Therefore Finding A Local Appraiser With Experience In Valuing Green Building and Energy Efficiency Features Is Easier



The screenshot shows the Appraisal Institute website. The header is red with the Appraisal Institute logo and tagline "Professionals Providing Real Estate Solutions". Navigation links include Home, Join, Media, Help, and a search bar. A prominent call to action says "Need Help? Call 888-7JOINAI (756-4624)" and "CLICK HERE TO LOGIN". The main navigation bar is orange and includes links for Membership, Find an Appraiser, Education, Publications & Store, Professional Practice, Lum Library, News & Advocacy, and About Us. The "Find An Appraiser" page is active, showing a breadcrumb trail "Home > Find An Appraiser" and a section titled "FIND AN APPRAISER". A "PLEASE NOTE" section states that search results are in random order by default and reset every 20 minutes. A "Notice" section clarifies that member information is provided solely by the member and is not reviewed or verified by the Appraisal Institute.

Appraisal Institute®
Professionals Providing Real Estate Solutions

Home | Join | Media | Help | Search
Need Help? Call 888-7JOINAI (756-4624)
[CLICK HERE TO LOGIN](#)

Membership | Find an Appraiser | Education | Publications & Store | Professional Practice | Lum Library | News & Advocacy | About Us

Home > Find An Appraiser

FIND AN APPRAISER

PLEASE NOTE: By default, all search results appear in **random order**. The random feature resets **every 20 minutes**. To view results in alphabetical order, please click "Edit Search Criteria" below and select "Name" in the "Sort by" menu on the Find an Appraiser main page.

Notice - Other than a member's membership designation, all other individual member information was provided solely by the member, and the Appraisal Institute has not reviewed or verified such information. The Appraisal Institute makes no representation as to the accuracy, completeness, or timeliness of the information in these listings and takes no responsibility for such information.

www.appraisalinstitute.org

Conclusions

- PV Costs are coming down
- Installations are increasing but there are still barriers
- Perceived price and ROI are important
- New data suggests PV home selling price premiums near net installed costs
- Options are emerging to pay \$0 down, and finance at a low interest rate.
- New tools are available to estimate selling price based on energy savings
- Growing number of appraisers with experience are available

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Lawrence Berkeley National Laboratory

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Link to report, 2-page summary, and presentation

<http://eetd.lbl.gov/ea/emp/re-pubs.html>

Citations

- Barbose, G., Darghouth, N. and Wiser, R. (2010) Tracking the Sun III: The Installed Cost of Photovoltaics in the U.S. From 1998-2009. Lawrence Berkeley National Laboratory, Berkeley, CA. December 2010. 54 pages. LBNL-4121E.
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- Farhar, B. and Coburn, T. (2008) A New Market Paradigm for Zero-Energy Homes: A Comparative Case Study. *Environment: Science and Policy for Sustainable Development* 50(1): 18-32.
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- SolarTech (2011) Solar PV Adoption Consumer Attitudes: Study and Recommendations for Marketing to Residential Consumers. Prepared for SolarTech, San Jose, CA. April 2, 2011.